Plan Overview

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Title: Spatial Cognition and its link to Mathematics Performance : What role can navigation and wayfinding play in supporting mathematics learning in children and adults (A Working Title)

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Project abstract:

Spatial and mathematic proficiency is an academic and economic gatekeeper that can limit the development of vital skills and academic achievements in both early childhood and into adulthood (Duncan et al., 2007; Frye et al., 2013). Compared to the performance of 40 other countries, mathematics performance in United Kingdom, as measured by the Programme for International Student Assessment (PISA), is ranked above the average (Organisation for Economic Co-operation and Development [OECD], 2016), however the gap between the highest and lowest achieving pupils in United Kingdom is above the OECD average. This means that although some children in England flourish, a worrying number of children in England are struggling to learn the basics of mathematics. In fact, when quantified, the size of this gap is equivalent to over eight years of schooling (Jerrim & Shure, 2016). The Confederation of British Industry noted similar problems in adults, estimating that 8.1 million adults aged 16 to 65 in England have Entry Level 2 or below numeracy skills (House of Commons, 2018). According to the Office of National Statistics (2020), this is equivalent to 19.6% of the population, aged 16 to 65 in England, demonstrating a numeracy level below what is expected of a 9-year-old child in primary education (National Numeracy, 2020). In context an adult at this level of ability may struggle to pay bills, work out a household budget, or understand their payslip (National Numeracy, 2020). Taken together, it is clear that mathematical proficiency remains an issue in England, with some research suggesting that poor mathematics skills have a bigger impact on employability and quality of life than poor literacy (Parsons & Bynner, 2005). Given the significant economical and societal impact of these problems, at both an individual and economic level, it is important to understand in detail the processes involved in learning and performing mathematics. In particular, this PhD will explore the novel role navigation and spatial skills more widely might play in supporting mathematics performance in both children and adults.

Time and time again, studies have demonstrated an association between spatial and mathematical aptitude in both children and adults (Geary et al., 2000; Young, Levine & Mix,

2018; Atit et al., 2020; Farmer et al., 2013; Newcombe, 2010; Mix, 2010). However, these associations between spatial and mathematical thinking are not always consistent (Xie et al., 2020). One explanation for differing spatial- math relations may be due to spatial and mathematics performance often being treated as singular constructs, whereas there is evidence that both domains are comprised of a multitude of sub-domains that are unlikely to be associated to the same degree (Gilligan et al., 2019; Fias & Bonato, 2018; Xie et al., 2020).

One subdomain of spatial thinking that is still largely absent from this literature is navigation. This was traditionally due to the large-scale nature of navigation and the logistical issues associated with testing navigation in real-world environments. It may also be that while navigation (wayfinding) appears to be a relatively simple concept, in reality, it is a complex multimodal process involving a dynamic interplay between perception, spatial memory, attention to landmarks and other features, as well as other non-spatial features, such as short-term memory and sensory input, which are needed for setting goals and decision making (Ekstrom et al. 2014; Garling et al. 1984; Montello 1998; Spiers and Gilbert 2015). Importantly, at any given time, all these cognitive processes may be at play simultaneously (Ekstrom, Huffman, & Starrett, 2017). For research purposes, it is important to group these elements of navigation, both behaviourally and neurologically, to better understand how they, not only interact with other cognitive abilities, such as mathematics and other spatial tasks, but also with each other.

The current research project aims to investigate the role navigation plays in mathematical performance, from a behavioural, developmental, and neurological perspective. This will not only improve our understanding of the navigation-mathematics association but also pave the way for the design of navigation training paradigms as a means of improving mathematics performance in children and adults.

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Copyright information:

Spatial Cognition and its link to Mathematics Performance : What role can navigation and wayfinding play in supporting mathematics learning in children and adults (A Working Title)

Data Collection

What data will you collect or create?

The project will collect quantitative data from both child and adult populations. For most of the project, the data collected will be new and the project will not be reusing any already collected and external data. However, roughly half of the data collected for our initial study has been carried out in collaboration with a Baily-Thomas Charitable Trust funded project. This project is still internal to the University of Surrey and the data will be shared openly between the two projects. This project will collect demographic data (e.g., gender, age, parents' SES) of each participant. However, identifiable data such as names will only be used as part of consent, parental consent, and child ascent forms. These will be kept separate from all other data.

The majority of the data output will be in Excel (xls) files that are either automatically generated from the completion of a computer-based task or manually inputted by the researcher who is monitoring the participants response. Data will be entered into these files manually when the participant is completing a paper based task. These completed paper tasks will marked with an anonymised unique reference number for that participant and stored in a locked cabinet at the University of Surrey's Stag Hill campus. Any data collected using task hosting platforms (i.e., Gorilla.sc) will be downloaded in .xls format and deleted from any third-party servers. For the neurological aspect of this project, channel configuration data (CCD) files will be an additional output, alongside .xls, during our electroencephalogram (EEG) tasks. These are all open and easily accessible formats which will allow the data to have long-term usability, easily shared as well as archived. Both formats are easily accessible through freely available software which are common practice within their respective fields.

As data collection is still ongoing, the size of the raw data, as well as the processed data can only be an approximation based on previous projects and data collected thus far. However, it will be a relatively small volume of data, as such this should not cause any issues with storage and management or pose challenges when transferring data. All raw and processed data is anonymised, containing no personal information, with each participant having a unique reference number allocated to their data set. These formats have been chosen due to the researchers experience and familiarity with the formats. This is also not uncommon within the psychology research community.

How will the data be collected or created?

The data will be collected in three forms across the project.

1) The developmental data will be collected from a typically developing population of 7-to-11-year-old children on across a range of navigation, other spatial abilities, and mathematics tasks in the child's school environment. The schools that have agreed to take part in the project will distribute an information document to the parents of all eligible students. This document will contain a link to an online consent form that the parent can complete on behalf of the child. This data will be downloaded and saved on the University of Surrey server, in a password protected file. All other data will be collected during in-person one-to-one sessions between the child and the researcher within the school environment. The formats for this data has been described within the previous question. All data will be stored on University of Surrey secure servers.

2) The behavioural data will use be collected using a closely linked battery of tasks to the study mentioned above. The data for this study will be created from an adult population at the University of Surrey. An online consent form will be presented at the start of the session that the participant will complete. All data from these forms will be downloaded and saved on the University of Surrey server, in a password protected file. The formats for this data has been described within the previous question. All other data will be collected during a computer-based session in-person at the University of Surrey.

3) The neurological data will be collected from both child and adult populations. All consent data from these forms will be downloaded and saved on the University of Surrey server, in a password protected file. All other data will be collected during in-person EEG sessions at the University of Surrey The formats for this data has been described within the previous question. All data will be stored on University of Surrey secure servers.

Raw participant data files will be labelled with the tasks name and their anonymised unique reference number.

Member of the research team will be allowed access to the anonymised data only. The staff members of participating schools, parents, or adult participants will not have access to data collected. However, parents of child participants, as well as any adult participants, will be made aware of their ability to request that their data collected or data from their child be removed from the project and destroyed.

Documentation and Metadata

What documentation and metadata will accompany the data?

A document describing the content of the Excel spreadsheets /or formatted files will be stored and archived together with the data to ensure future access and secondary uses of data. This will include the title of the project, contact details for the Primary Investigator, the time period of data collection, the format and size of the data, alongside information and the final version of the protocol used. The protocol will outline all the required information regarding the methodology and software used.

Ethics and Legal Compliance

How will you manage any ethical issues?

For any child participant, consent will be given on behalf of a part of guardian, which will be included within the information document. All child participants will also be asked for verbal ascent before the start of each session. All adult participants will be asked to give consent by completing the appropriate form which will be included with the information document relevant to the study. The request for consent will make clear that they have read and understood the information/parental information sheet, that their participation/ child's participation is voluntary and they are free to withdraw at any period and under no obligation to complete all of the tasks. At the start of the sessions it is made clear once again by the researcher that the participant is free to return to class/leave at any point and there is no obligation to stay or take part in the remaining tasks.

All personal information (identifiable information) will be stored for six years on University of Surrey secure servers, as per protocol. This information will be kept separate from all other data in a password protected document, that is only accessible by the Primary Investigator.

It will be made clear to the adult participants, parent's of child participants and child that their data may be used and shared with other researchers in anonymised form but that their individual data will not be identifiable in any outputs. Participants and parents will be informed that information provided will be used in various anonymised outputs (such as conferences, and journal publications) and that no identifiable information will be produced.

Raw data will not be shared in any form and only accessible to the research team.

How will you manage copyright and Intellectual Property Rights (IPR) issues?

Copyright and Intellectual Property Rights will be maintained by the University of Surrey on behalf of the Principal Investigator.

Storage and Backup

How will the data be stored and backed up during the research?

The Principal investigator will be responsible for the storage and backing up of data. The data will be stored on University of Surrey secure servers. The Principal Investigator will save a copy of this data on University of Surrey servers in two locations. One folder for data processing and analysis and a master copy of the raw data - this is in case files used for analysis become corrupted. University Servers are secure, password protected and regularly backed up by IT.

How will you manage access and security?

Access to the data will only be by the Primary Investigator and supervisors. Identifiable information such as names are not accessible to the research team.

Selection and Preservation

Which data are of long-term value and should be retained, shared, and/or preserved?

The data that will be shared is anonymised and no participant information, such as names, will be contained within the data file. Data will be kept and archived together with a metadata document and the protocol. Participant Information will be kept separately

and will only be available to the primary investigator, this is in case a participant wishes for all their data to be removed from the project. The anonymised data file and the protocol will be openly available for secondary usage through the University of Surrey data repository. Permission to share all anonymised data will be grated though all consent forms. On completion of the project, data will be archived in accordance with the University policy on secure drives and stored for 10 years.

What is the long-term preservation plan for the dataset?

The anonymised data files and the protocol will be openly available for secondary usage through the University of Surrey data repository. These files will be uploaded in parallel to their corresponding publications. Permission to share all anonymised data will be grated though all consent forms. Data will be archived on secure University servers for 10 years inline with the University of Surrey's Open Research Policy, there is no anticipated cost of keeping the data for this time.

Data Sharing

How will you share the data?

A final report summarising the main findings of the study will be produced and shared with the schools that took part. Parents of the participants can also request a final summary report by emailing the Principal Investigator once the study has been concluded. The research findings will also be reported as a peer-review scientific article and conference presentation with published findings maintaining participant confidentiality and anonymity.
The anonymised dataset will be openly available for secondary analysis etc. Any request will be handled by the Primary Investigator and by the research team. Any
potential future user will be able to email the Primary Investigator or the supervisors to enquire about the data and discuss its suitability for any intended secondary uses.

Are any restrictions on data sharing required?

No exclusive use of data will be required. The Primary Investigator and the research team will be willing to discuss any secondary uses for data collected in this project, data will be shared with other researchers and will be openly available in its anonymised data set.

Responsibilities and Resources

Who will be responsible for data management?

The Principal Investigator of the project will have overall responsibility for ensuring the integrity and security of data. As well as the responsibility for the day to day management and upkeep of the datasets, meta-data and supporting documentation production.

Supervisors Dr Katie Gilligan-Lee and Prof. Emily Farran will have oversight of the data management processes and ensure the researcher adheres to this data management plan.

What resources will you require to deliver your plan?

No additional resources will be required.